NIST-GCR-91-591

Estimated Impact of the Center for Fire Research Program on the Costs of Fire

Philip Schaenman

TriData, Corp.
Arlington, VA

Sponsored by:
U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Building and Fire Research Laboratory
Gaithersburg, MD 20899

U.S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
John W. Lyons, Director

NIST

NIST-GCR-91-591

Estimated Impact of the Center for Fire Research Program on the Costs of Fire

Philip Schaenman

TriData, Corp.
Arlington, VA

January 1991

Issued June 1991

Sponsored by:
U.S. DEPARTMENT OF COMMERCE
National Institute of Standards
and Technology
Building and Fire Research Laboratory
Gaithersburg, MD 20899

U.S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary
NATIONAL INSTITUTE OF STANDARDS
AND TECHNOLOGY
John W. Lyons, Director

Notice

This report was prepared for the Building and Fire Research Laboratory of the National Institute of Standards and Technology under 43NANB107753. The statements and conclusions contained in this report are those of the authors and do not necessarily reflect the views of the National Institute of Standards and Technology or the Building and Fire Research Laboratory.

ESTIMATED IMPACT OF THE CENTER FOR FIRE RESEARCH PROGRAM ON THE COSTS OF FIRE

Prepared For

The Center For Fire Research

National Institute of Standards and Technology

By

Philip Schaenman

January 1991

TriData

A Member of the SPC Group

ESTIMATED IMPACT OF THE CENTER FOR FIRE RESEARCH PROGRAM ON THE COSTS OF FIRE

Prepared For

The Center For Fire Research

National Institute of Standards and Technology

By

Philip Schaenman

January 1991

TABLE OF CONTENTS

INTRODUCTION		1
IMPACTS		7
A.	Automatic Detection	7
B.	Automatic (Built-in) Fire Suppression	14
C.	Building Design and Codes	24
D.	Safer Consumer Products	30
E.	Major Fire Investigations	39
F.	Firefighting Tactics and Technology	40
G.	Flammability and Toxicity Tests	45
H.	Transportation Safety	50
I.	Ad Hoc Consulting	51
SUMMARY		64

EXECUTIVE SUMMARY

The Center for Fire Research (CFR) has had a huge impact on reducing casualties and losses from fires.[1] It also has helped stimulate new industries, and saved industry enormous sums by engineering fire safety better, averting business disruption, reducing liability, and in a number of other ways. The dividends of the past continue; CFR's budget essentially has been "paid" through the Year 2100 by even the most conservative estimates of its impact.

This was a first, brief effort to estimate the magnitude of the CFR impact, and how it is distributed across the major components of the total cost of fire. More work is needed on virtually every aspect of the estimation procedures used here.

Impacts

1. By even crude first estimation, the CFR program has an enormous impact on the cost of fire: on the order of $6 - 9 Billion annually in cost-benefits for the base program, and $16 - 26 Billion annually at the proposed enhanced level Five-Year Plan. The savings would be considerably greater if secondary impacts were considered on business interruption, insurance, and fire service costs. A summary of the CFR impacts versus the costs of fire are shown in Table 1.

2. The CFR Base Program stimulates at least $350 Million - $1.4 Billion in added industrial sales annually. The enhanced budget would result in $1.7 - 5.2 Billion in sales per year.

---

[1] The Center for Fire Research, a unit of the National Institute of Standards and Technology (NIST) became part of the new Building and Fire Research Laboratory at NIST toward the end of this study.

Table 1. Summary -- Impact of the Center for Fire Research Program

	Total Costs ($ Billions)		Savings ($ Billions)	
	Category	Component	CFR Base Budget	CFR Enhanced Budget[1]
A. Losses	30.7			
Residential Losses				
Property		4.0	1.7-4.2	1.6-3.8
Deaths and Injuries		7.3		
Non-Residential Losses				
Property		4.9	.6-.8	.4-1.2
Civilian Deaths and Inj.		1.8		
Residential Interruption		0.8	Not Estimated	
Business Interruption		8.4	Not Estimated	
Product Liability		3.5	.2-.3	.1
B. Insurance	5.7		Not Estimated	
C. Fire Service	43.2			
Costs		39.6	.2-.5	.6-2.2
Deaths & Injuries		3.6		
D. Preventative	48.5			
Built-In Structures		20.7	2.6-3.6	6.6
Built-In Equipment		18.0	.1+	.8-1.6
Standards		0.2	N/A	.02-.04
Retardants/Testing		2.5	.02	.2-1.1
Fire Maintenance		6.5	N/A	
Disaster Recovery		0.6	.1+	
TOTAL	128.1		5.6-9.4	10.4-16.7

NOTES: Total corrected for roundoff error. "Savings" include cost of injuries and deaths. Non-residential Property loss includes "industrial" and "other."
The "Enhanced Budget" impacts are over and above those of the base budget.

3. CFR's impacts tend to be long-lasting. Virtually every major contribution from the 1970s still is paying off.

4. Though CFR work touches virtually all aspects of the fire problem, the largest impacts of the base program fall into two areas:

   - Built-in fire protection of structures
   - Residential life safety

   Under the baseline budget CFR would not have a major impact on the costs of the fire service and of fire protection built into equipment -- two of the largest components of the total cost of fire.

5. Under the proposed enhanced CFR budget, the largest additional impacts would again be in built-in protection of structures and residential life safety. There would also be some significant impact on the built-in safety of equipment, and firefighting costs, but CFR might consider whether larger impacts are possible in these two major cost areas.

6. The large cost of the fire service -- mainly labor costs of the paid service and the equivalent cost of labor for volunteers -- is not much affected <u>directly</u> by CFR's program. However, the cost of fire services might be higher if there was not as much built-in safety in buildings today. In the long run, a safer built environment reduces the need for manual suppression. Nevertheless, as noted above, CFR should consider whether it could play a larger role in the equipment and operation of the fire service.

7. Costs of insurance are significantly affected by reduced fire losses, especially in non-residential buildings. Though not estimated, CFR's large contribution to built-in safety undoubtedly affects this cost, too.

8. Business interruption costs likewise are reduced by preventing fires and keeping them small. Though not estimated, CFR's impact on built-in safety undoubtedly plays a role in reducing or holding the line on these costs.

9. Fire maintenance costs may be increased or decreased as a result of the CFR program. Built-in systems require monitoring and testing. However, as the built-in safety is made more reliable, and proven to be reliable, the costs of fire maintenance could decrease. The impact of CFR on this area deserves more consideration in the future. Just as the military now consider the total cost of systems as including their maintenance, so should fire protection systems.

Ad Hoc Consulting

1. The CFR day-to-day consulting uses a significant amount of staff time and provides a valuable service that alone could justify half the CFR budget. However, this large free service to industry has relatively low leveraging compared to other parts of the program, and receives virtually no credit. Consideration should be given to somewhat curtailing this activity, and channeling the time into higher leverage areas.

2. On the other hand, CFR might consider an increased travel and time budget to do more consulting for standards committees, where the potential leverage is high.

3. CFR also might consider increased "advertising" of the availability and usefulness of its products, to reach many who now receive one-on-one advice about them.

Estimation Methodology

Among the major methodological problems in estimating impacts of the CFR program are:

- How to apportion credit to CFR viz a viz other players, e.g., in reducing costs of automatic sprinklers, or the lives saved by smoke detectors.

- How to compute secondary impacts on insurance, fire service labor, fire system maintenance, and business interruption.

- Distinguishing continued savings from past achievements versus savings from the continuing baseline CFR program. We have grouped the two effects, here, on the grounds that most of the contributions since 1975 seem to be still producing savings.

All of these methodological issues need further attention. A second pass at estimating the cost benefit of the program, using this report as a starting strawman, is recommended.

INTRODUCTION

The Center for Fire Research at NIST has been at the center of research on the fire problem in the United States for most of this century and is a principal contributor to fire research internationally. This paper summarizes the major impacts of the CFR program, including cost-benefit estimates where possible. It also discusses the likely impact of some of the current and planned parts of the program. The future impact is considered both at current and enhanced budget levels.

The Center for Fire Research's impact is difficult to capture for several reasons. Most of the Center's work is highly technical. Much of the Center's role, by design, is to apply its expertise in science and technology to initiating the development of a new technology or method, or to eliminating technical roadblocks to delivering finished products. There are major exceptions, such as fire test procedures and fire models where "finished products" have been developed, but by and large the Center gets something started and leaves it to industry to develop fully and commercialize. The Center's contribution therefore also is hard to estimate quantitatively because it is an integral part of efforts involving many organizations, and because the Center is involved in so many activities and contributes on so many levels -- scientific papers, code making, supporting the research of others, ad hoc consulting. In fact, many of the Center staff interviewed for this study had difficulty recalling all of the significant efforts they personally had been involved in.

Despite the inherent difficulties, however, understanding what the CFR contributes is important for informed decision making about its future direction and resource requirements.

Purpose

This paper is intended to help make the role of CFR and its breakthrough contributions more readily understandable to people in the fire service and the citizens who have paid for them. The assessment here is also intended as input to formulating the strategy of the CFR program and its goals for the future.

This is a first rough cut at a very complex task. Estimating the impact of each area of CFR's program is a small research project itself. Nevertheless, even in making a first crude pass, one is quickly overwhelmed by the order of magnitude of the impacts in the many areas CFR has touched. It is equally clear that much of the contribution is not widely known, nor totaled up. It is hoped that this paper will contribute toward these objectives.

Scope and Emphasis

This brief study was based largely on interviews with CFR staff. It is not an exhaustive review of CFR documentation. As a result, it focuses more on the immediate past, the present, and short-term future. Major contributions known to the author or mentioned by the staff from the past ten years or so were included, but some important impacts may have been left out because of the reliance on oral history.

Included here are scheduled projects under CFR's budget, projects that CFR undertook for other agencies, and ad hoc consulting efforts.

The report may not do full justice to the more theoretical side of CFR's research. None of those researchers were interviewed. Their colleagues' interpretation of how the work feeds into various modeling efforts and as background for consulting was included. There may be other paths of impact not considered here.

With a few exceptions, we will not discuss the impact of fire research conducted in universities that is supported by grants from CFR. The focus is on projects that the CFR staff itself has undertaken. [2]

There are many day-to-day contributions made by CFR that also are difficult to reflect. Many are in the form of a continual series of "consulting calls" received from industry and fire protection experts nationwide. Often a few hours of consulting saves thousands or even millions of dollars in better directed development or research. We give examples of this effort and a rough estimate of its magnitude. Having a pool of talented people engaged in the forefront of an area of research enables a significant amount of such "consulting" to be done.

Organization

There is a dilemma one faces when describing the CFR program: whether to discuss it in terms of the functional areas of CFR (e.g., fire testing, mathematical modeling) or in terms of practical outcomes (e.g., safer upholstered furniture, smoke detectors, transportation safety) or in terms of the CFR targeted objectives (e.g., "engineered fire-safe products," and "sense and communicate risky conditions"). We have opted for a mix, with a bias toward describing things in terms of products or services likely to be understood by the average person.

Frame of Reference for Assessing CFR Impact

The achievements and plans of CFR can be assessed against various sets of criteria. We consider two major frameworks here.

---

[2] It would be useful to consider the impact of the extramural research in a future study.

One is the viewpoint of fire protection: what are the casualties and property losses averted? How is the efficiency or productivity of fire protection increased (i.e., doing the same or more with less)?

The second viewpoint -- not at all inconsistent with the first -- is that of the Department of Commerce strategic goals: improve U.S. industry's competitiveness and assist the U.S. economy by such actions as improving the quality of products and services, speeding up the commercialization of new or emerging technology, and assisting in the reduction of legal barriers (e.g., by developing standards and quickly settling litigation issues).

We discuss the various areas of impact of the CFR program in enough detail to consider both of the above frames of reference. In the concluding section of this report, we summarize the achievements from both viewpoints.

There are five specific types of impacts considered in this study. They are not all commensurable even though all can be expressed in dollars, and so they are often described separately.

1. *Reduced Losses* -- Dollar values of direct losses, and cost-benefit estimates of the dollar values of deaths and injuries. Indirect losses were not estimated here. The total contribution to losses averted therefore is higher than we estimate here. In a number of cases only reductions in deaths and dollar loss were considered, partly to save time, and partly because the cost-benefit impacts of the injuries tends to be much smaller than the deaths. Injuries are "valued" at $40,000 per capita, deaths at $1.5 Million, as has been done in recent CPSC and CFR

studies.[3] Since the ratio of injuries to deaths tends to be 3 - 5 to 1, and the "cost" ratio of deaths to injuries almost 40 to 1, injuries can be virtually ignored for the cost-benefit studies. We include them in a few places, to illustrate their impact.

2. *Savings to Industry* -- These are reduced costs of engineering, construction, testing, and the like -- things that would have to be done, but can be done less expensively because of the CFR contribution.

3. *New Markets or Added Sales* -- Some of CFR's contributions help open up new industry or new markets (e.g., a new generation of smoke detectors or sprinklers.) Sometimes, new technology requirements are one industry's gain and another's increased cost (e.g., flame retardants going into upholstered furniture.) However, the industry whose product value is added to often passes on the cost to the customer, increasing their own sales too. We simply state the size of the market where known, or its order of magnitude. Not considered here is the impact on the GNP via multipliers.

4. *Liability Reduction* -- Much of CFR's modeling and knowledge of the physics and chemistry of fire are useful in litigation. Because of the litigious nature of our society today, law cases tend to bring in everyone with deep pockets who can possibly be identified. "Quantifying and communicating fire risk and hazards," a CFR Five-Year Plan goal, tends to work toward reducing litigation and its cost by making it possible to demonstrate what products, materials, or structural features were or were not significant, and by increasing fire safety and hence reducing the number of cases to litigate. Also, CFR's enormous impact on codes and standards works toward giving manufacturers and designers some protection if

[3] "Toward a Less Fire-Prone Cigarette," Final Report to the Congress, Technical Study Group on Cigarette and Little Cigar Fire Safety, Cigarette Safety Act of 1984, 1987. Copies are available from the Consumer Product Safety Commission.

they abide by those codes and standards. The net impact on liability reduction is significant but hard to measure. We note it qualitatively or quantitatively where possible.

5. *Insurance Impacts* -- Many contributions of CFR make the world safer, or reduce the cost for maintaining a given level of safety. To the extent that insurance costs are based on risks, the cost of insurance should decrease somewhat to offset increased costs of the investment in safety. We have not explored whether such insurance offsets occur or their magnitude.

CAVEAT: In the next section, we consider the various areas of impact. The dollar estimates here are meant to give a feel for the order of magnitude of the impact of the CFR program, and its potential. More careful studies are needed to refine virtually every estimate presented here. The assumptions and computations are shown explicitly so that others can make their own estimates. We try to indicate the factors in each estimate where specific dollar estimates did not seem feasible for even the order of magnitude.

IMPACTS

A. Automatic Detection

1. *Launching the Smoke Detector Revolution*

The Center for Fire Research helped cause the explosive spread of smoke detectors throughout the United States. An entire industry has sprung up to produce residential detectors. There also have been large increases in the industrial fire protection industry, not to mention major impacts on battery sales and electrician services (for the installation of hard-wired detectors.)

There is no question but that thousands of lives, much property loss, and many calls to fire departments have been prevented since 1975 by the use of these smoke detectors. Based on the U.S. example, detectors are also being sold in many other countries. In Britain, for example, about a third of households now have them, in a program that they admit is based on the U.S. experience.

This truly worldwide impact was directly stimulated by CFR. It is the quintessential example of asking the right technical question at the right time. Some key changes in detector technology made a revolutionary difference.

The crucial CFR work was to raise the question and then discover the answer as to why many smoke detectors sold around 1965 did not work as advertised.[4] In many cases they did not go off in the presence of heavy smoke. The detector "disappeared in the smoke, but did not go off," said Richard Bukowski, one of the early principal

[4] CFR had been asked to provide the technical specifications for the detectors to be used in "Operation Breakthrough," a HUD initiative to improve low cost housing. Dick Bright of CFR found that the available detectors did not work well.

researchers on the problem. These early detectors were based on the photo-electric principle, and required heavy baffling from outside (ambient) light to avoid continually alarming. Unfortunately, the baffling that was intended to keep out unwanted light also succeeded in keeping out much of the smoke, thereby delaying the alarm. There was no U.L. standard for detectors at that time. [5]

Once this problem was pointed out to the manufacturers, they quickly found ways to solve it, with advice from CFR. The rest is history; the breakthrough in design led to favorable press reports, which led to more consumer interest and then a burgeoning demand for detectors. The increased volume lowered the price, stimulated further marketing by the manufacturers, and created a positive feedback spiral which led to the price diving and demand rising further. The United States went from having less than 5 percent of homes equipped with detectors in 1975 to having about 85 percent today. About 98 percent of hotel rooms have detectors, too, which helped cut the hotel fire death rate to less than half what it was.

CFR also made a critical contribution on testing detectors and specifying standards for reliability. CFR recommended using an adaptation of military electronics reliability specifications for the domestic market for the first time. This led to Underwriters Laboratories test criteria and to UL 217, the test standard on which the reliability of detectors is based. Much of the standards development was performed by IIT Research under funding and guidance of CFR.

CFR also has helped contribute to the general acceptance of detectors by the public. CFR has analyzed many fires that showed that had detectors been present, the majority of fire deaths would not occur.

---

[5] Richard Bukowski had been sent by UL to participate in the CFR research on detectors, and became a member of the CFR staff.

Estimated Impact – A large number of people have been saved in the past 15 years because of smoke detectors. The basis for this statement is many documented anecdotes and the halving of death rates per fire when working detectors are present. [6] Were it not for the key initial work by NIST, the detector revolution might not have occurred, or would have been significantly delayed.

To estimate the savings, consider that residential fire deaths have dropped by about 3000 deaths per year since residential detectors started becoming popular c. 1975. Since that time, design of homes has tended toward increased hazards (more plastics, smaller rooms, faster flashover, higher toxicity.) The major factors working in the opposite direction have been detectors, less smoking, safer mattresses and upholstered furniture, and more public safety education.

Less than one-third of residential deaths involve mattresses and bedding. Even if safer mattresses and bedding are credited with all of the drop in that category (roughly one-third of the deaths), that still leaves 2000 per year for detectors and public education and other factors. An estimate of half the 2000 – 1000 lives saved by detectors per year – would not be unreasonable. Given the increase in U.S. population by 15 percent since 1975, the reduced deaths could well be 15 percent higher, too, since fire deaths would normally be expected to increase proportional to population.

If CFR is only credited with speeding up the use of smoke detectors by one or two years, the overall impact of CFR may have been 1000 - 2000 deaths averted x $1.5 Million per life saved = $1.5 - 3 Billion. It can be argued that the CFR contribution could have speeded up the commercial boom by five or ten years, for a $7.5 - 15 Billion

---

[6] Fire in the United States, Second Edition, United States Fire Administration, Washington, D.C., July, 1982, p. 176.

cost-benefit, and that there is a residual "credit" to CFR of, say, one-tenth of the annual lives saved by detectors ($0.15 - 0.3 Billion per year.) [7]

Detectors also save property and reduce medical costs by early detection, but there are no satisfactory estimates of the injuries and damage averted, much of which is unreported because the fires are detected when small enough to be extinguished by occupants and not reported to the fire department.[8] If each household with a detector has 1 - 2 unreported fires averted in 10 years due to detectors, and those fires averted a conservative $100 - 500 damage per fire, then 64 million detectors minus 16 million (one-quarter) not working = 48 million detectors x 0.1 to 0.2 unreported fires detected each year x ($100 - 500 loss per fire) = $0.5 - $5.0 Billion per year. If we assume CFR has a residual 10 percent contribution, that is $50 - 500 Million per year. (Another interpretation is that there is $100 - 500 reduced loss from reported fires in some cases.)

As a result of the expanded use of detectors, new detector companies and subsidiaries sprang up. Over $1 Billion has been spent on residential detectors. (Eighty percent of households x 80 million households x 1.5 detectors per household x $10/detector) = $920 Million. Early detectors cost $20 - 50, so the total is over $1 Billion.)

Detectors are recommended to be replaced after 10 years. Assuming 10 percent will do it per year, that is $100 Million per year replacement market starting over the next few years, especially if the fire world gets behind this. Also, the remainder of the

---

[7] There were fewer lives saved by detectors in 1975 than 1990. A revised analysis could look at the year to year reduction in deaths versus the increase in households with detectors. A regression analysis of deaths versus detector use would also assist in making this estimate.

[8] Residential property loss has risen per fire since the introduction of detectors. That may be due to more serious fires, or to fewer minor fires as a result of early detection.

population without detectors is still gradually buying them -- about 1 percent of households more per year, or (.8 million x $10) = $4 Million. Hard-wired detectors cost about $50 to install. In the approximately 20 percent[9] of households with hard-wired detectors, that is another market of (64 million households x .2 x $50) = $640 Million to date, and perhaps 10 percent of that in replacements per year ($64 Million).[10]

About 80 percent of detectors are battery-operated; this adds (.8 x .8 x 80 million x 1.5 x $1-2 per year for batteries) = $75 - 150 Million <u>per year</u> potential market. However, about 1/4 x 1/3 are not replaced or used for other purposes. Thus the total is more like $60 - 120 Million per year for batteries. Thus in addition to the $1 Billion invested, there has been at least another $2 Billion in batteries in the past 15 years. Detectors surged in the early 80s but the early detectors required batteries that cost $5 to $9 each.

2. *New Detection Technology*

At present, it is thought that about one-third to one-half of all detectors in U.S. homes are not in operating order due to removal of batteries, dead batteries, or

---

[9] Rough approximation; the proportion of hard-wired is increasing over time, as detectors are mandated for new properties.

[10] This should be cross-checked if possible with industry sales figures; we used industry costs per unit, and estimated the unit sales potential.

deterioration of the detector.[11] Another problem is the high false alarm rate of current detectors in both residential and commercial settings.

CFR has not recently, and does not plan to work on detectors under a base-level budget.

At an enhanced budget level, CFR would be able to assist in the creation of smart, low-cost detectors, using new sensing technology and built-in signal analysis. One would like to have a microelectronics chip that matched the performance of a human nose -- sensors that can "smell" smoke. One might also consider varying the sensitivity of the detector by people's actions: more sensitive when people are asleep and no cooking taking place, or when people leave a room. Smart sensing might be able to determine whether smoke being sensed was from a cigarette being smoked or a cigarette smoldering on furniture (e.g., by sensing the presence of urethane products of combustion.)

The new detectors would yield fewer false alarms and provide earlier detection of real fires. One key to designing smart detectors is understanding the characteristics of household smoke and fumes that are not from unwanted fires. (CFR has already a strong knowledge of smoke particulate characterization which has helped industry select between ionization and photoelectric detectors.)

---

[11] A research project by USFA, CFR or someone else is urgently needed to determine the failure rates of detectors in the field, and to sort out the reasons for the failures, such as sensitivity drift, electronics or sensor failure, and lack of routine maintenance (cleaning and battery replacement). As more codes mandate hard-wired detectors for many buildings, there is also the question of their vulnerability to electrical current surges, such as caused by thunderstorms, and how they might be protected.

Potential Impact – In an estimated 13 percent of fire deaths a detector is present but did not operate. In another 18 percent the detector did operate, but sometimes too late.[12] In 69 percent of the deaths, no detector was present. A new technology could affect at least the first two problems by being more reliable and more sensitive to real fires (and hence give earlier warning.)

If a new technology reduced by 50 percent the present situation where 31 percent of residential fire deaths occur with "detectors not operating" or "present but not effective," then .5 x .31 x 5000 deaths = 800 deaths that might be averted annually, for a cost benefit of $1.2 Billion per year. This total could be higher if the 69 percent of deaths without detectors was reduced by greater use of current technology, with the same problems previously mentioned. Thus the lives saved might be 800 - 1600, or $1.2 to $2.4 Billion.

In addition, there would be a reduction in dollar losses from the 18 percent of residential fires where a detector currently is present but doesn't operate.[13] In these 18 percent of residential fires, a detector was present but did not operate in 45 percent of the cases; half of these were because the fire was too small. So, if we assume that in 20 - 25 percent of the 18 percent (where the fire was not small) a better detector would reduce losses by 50 percent through earlier detection, that would mean (18 percent of residential fires x $4.0 Billion residential loss in 1989.[14]) x .25 x .5 = $90 Million per year. The new detectors may not reduce losses by 50 percent, but on the other hand there are another 55 percent of the 18 percent of fires where a detector did go off but losses were still incurred; some of these fires probably could have lower losses if the detector went off earlier than it did.

---

[12] Fire in the United States, 1983-1987, Seventh Edition, United States Fire Administration, 1990, pp. 77 - 80.

[13] Ibid.

[14] NFPA Fire Journal, September/October 1990, p. 61.

New detector technology also could make a significant reduction in non-residential losses. Detectors are far less present in commercial properties than residences, and thus there is a greater potential impact on losses. We estimate 10 - 20 percent saving of the 65 percent losses in non-residential occupancies associated with fires that do not have working detectors present.[15], [16] That would be (.1 - .2) x .65 x 3.5 Billion non-residential structures less in 1989 = $.23 - .46 Billion. [17]

New detector technology also could lead to a major new market. Just in the U.S., 1.5 new detectors per home x 80 million homes x $10 - 20 per detector = $1.2 - 2.4 Billion in new sales in the residential market alone, plus another 3 million rooms in hotels and motels. New detectors might have features costing $50 - 100 that many might buy or that might be specified. Also, the industrial market for better detectors is vast -- $5 to 10 Billion total. Any new detector technology now would have a worldwide market, too.

B. Automatic (Built-in) Fire Suppression

Sprinkler systems and halon fire extinguishing systems have long been proven to be extraordinarily effective in reducing property losses and improving the life safety in structural fires. Estimates of the reduction in fire losses from sprinkler systems are on

---

[15] From NFIRS 1987 summary computer printouts produced by Tom Collins, FEMA.

[16] An analysis is needed of a few representative industrial fires to see what portion of the loss could be averted by earlier detection.

[17] We use the NFPA non-residential structural fire loss for 1989, from NFPA Fire Journal, op. cit. The assumption is that property losses in industrial fire brigades are more likely to have detectors or sprinklers already -- which may be questionable, in which case the impact of new technology could be increased by 50 percent, to $ .63 Billion.

the order of 90 percent or higher. Sprinklers are becoming more and more widely spread, especially in commercial buildings and institutions.

The main problem in use of sprinklers is how to reduce (or overcome objections to) the initial costs of the systems, especially for homes. It also is crucial to ensure the reliability of sprinkler systems and to be able to verify their status. Design aids to handle unusual places such as aircraft hangars also are needed.

1. *Improving Efficiency and Use of Automatic Sprinkler Systems*

NIST has assisted the sprinkler industry in developing computerized tools for solving sprinkler engineering problems -- both to maximize the efficiency of the systems and to solve complex design problems. This affects the cost of fire protection to industry, the effectiveness of sprinkler systems, the size of the sprinkler industry (now $3 Billion sales per year), and ultimately safety and losses. Installation of a sprinkler system is perhaps the largest step forward one can take for improving the fire safety of a building.

Whenever a sprinkler system is installed the expected dollar losses from fires usually go down sharply. Insurance premiums may also go down sharply if the property would be high-risk without them. (The insurance impact of installing sprinklers in a wood-frame restaurant is greater than in a concrete apartment building.) The value of the structure may increase from installation of sprinklers; or the cost of construction may drop as sprinklers allow a less fire-protected type of construction to be used. These advantages usually offset the cost to the owner of the sprinkler system, and in the process stimulate plumbing and engineering service business. It is a win/win situation.

The prime reason many buildings do not have sprinkler systems is that they are not required to have them by either codes or insurers, rather than price resistance from

individual purchasers. [18] Reducing costs, such as by using fewer sprinkler heads, smaller water pipes, or thinner-walled pipes while still maintaining system effectiveness increases the affordability and hence the spread of sprinklers by an interesting mechanism: The people who serve on codes committees and those who set insurability requirements are more likely to require sprinklers if they appear to be economically acceptable to building owners. Historically, codes first allow sprinklers as an option in tradeoff against other building features . As costs go down further and the simplicity of installation increases, a wider range of occupancies are required to have sprinklers as opposed to leaving them as an option.

Thus finding a way to reduce costs for a given level of effectiveness not only has a first order effect on the price to the building owners, but contributes to a secondary cumulative effect that can dramatically increase the market for sprinklers.

Another reason (besides costs) for not using sprinklers is complex geometry, and a third is objections to their aesthetics. Finding better ways to cope with various kinds of sloped ceilings, obstructions by alcoves, etc., and ways to fit in aesthetically without ruining historic ceilings, for example, also increases the market for sprinklers.

Much of sprinkler installation today is based on cookbook formulas and trial and error. The sprinkler industry needs a better way to predict performance. A CFR staff member reports witnessing the trial and error process of installing a sprinkler system in a large aircraft hangar, which repeatedly failed to meet aviation fire protection standards (flow tests) while different spacing and angling of sprinkler heads was tried.

---

[18] According to the National Fire Sprinkler Association Private communication with John Viniello and Russell Fleming, December 1990, most sprinklers are sold where they are required. Individual building owners tend not to be the ones to decide on sprinkler desirability; they either go along with requirements or do not buy the systems.

The sprinkler/detector activation program that NIST has developed, called DETACT, can aid the design of such sprinkler systems. The DETACT program allows one to answer the question of whether you can move or decrease the number of sprinkler heads and still have an equivalent system that will pass code.

A nationally important example of NIST's ability in sprinkler engineering was the installation of sprinklers in the U.S. Capitol. NIST helped save an historic ceiling by recommending the installation of faster response time heads lower than the ceiling, thereby eliminating the requirement to punch holes in the ceiling. This not only reduced costs, but made installation feasible without destroying historic value.

NIST also is undertaking a modest research program to better understand the time delay before activation of sprinklers, and the performance of sprinkler heads other than pendant-type, such as recessed heads. Recessed heads increase aesthetic appeal which in turn increases demand, but their relative effectiveness needs to be determined.

Estimated Impact – The NIST contribution to engineering refinements of sprinkler systems is estimated to have reduced the costs of current sprinkler systems in commercial and residential properties by approximately 5 percent. Since the market is $3 Billion per year, that is a $150 Million per year impact on costs saved by industry.[19] This cost reduction also helps increase the size of the market by making sprinklers cheaper and more flexible in applications where sprinklers are not now thought cost-effective and are not mandated. The sprinkler market has tripled in dollar volume and increased by an even larger multiple in terms of pipe laid over the past 10 - 15 years as a result of cumulative cost reduction and engineering improvements to which NIST has contributed.

[19] It was felt that the impact was more than 1 percent and less than 20 percent by both the National Fire Sprinkler Association and TriData – but this is obviously a rough estimate.

Sprinkler systems also have contributed to the downward trend in non-residential property loss over the past two decades in real dollars. From 1983 to 1987, for example, the losses fell 12 percent.[20] The percent of non-sprinklered non-residential buildings involved in fires dropped from 62 percent in 1983 to 52 percent in 1987; however the percent with status unreported increased from 29 percent to 38 percent, so it is not clear how large an increase in sprinklerization took place. The average loss per fire with and without sprinklers yielded anomalous data; we cannot yet estimate the savings in losses from sprinklers other than to know they are probably in the billions per year; losses per year are down while the volume at risk has increased enormously. NIST's "5 percent" contribution is on the order of \$.05 x 4.2 Billion in losses - \$200 Million per year in loss reduction for industry.[21]

2. *Detectors in Sprinklered Health Facilities*

One of the most recent sprinkler studies at CFR considered, at the request of the National Institutes of Health, whether detectors were needed in health care facilities in addition to sprinklers, or could sprinklers alone maintain a tenable environment in the event of fire? The analysis required consideration of the response times of the latest sprinklers. The NFPA Committee on Safety to Life concluded that the detectors were not needed. The study results were a factor in the Committee's decision.

Estimated Impact -- Potential savings of \$1 Billion on unneeded detectors and their maintenance, based on the above study.

---

20 Fire in the United States, 1983-1987, p. 153.

21 The losses without sprinklers would be much larger than the \$4.2 Billion currently obtained with them, so this estimate is conservative in that respect, even though the "5 percent" allocation is soft.

3. *Sprinkler Module for HAZARD I*

Another product planned as part of the CFR enhanced five-year plan is a sprinkler module for the HAZARD fire growth computer model. The model is discussed below under Building Design and Code. The new sprinkler module will allow the effects of a sprinkler system to be taken into account in the modeling of fires in buildings. Besides its impact on building design, the model will be able to provide a dramatic demonstration of the effectiveness of sprinkler systems, thereby increasing the sales potential by demonstrating to both average and sophisticated users the benefits of a system in their building. More importantly, it can be used to help test the likely benefits of code changes or insurance requirements.

Estimated Impact -- An increase in sales of 2 - 4 percent may be possible from this added proof, or $60 - 120 Million a year.

The new sprinkler module also is expected to play a major role in litigation. The presence and operations of sprinklers is one of the primary litigation issues today. The 1984 DuPont Plaza hotel fire in Puerto Rico ultimately will lead to over $1 Billion litigation by the time all suits are completed, as did the MGM Grand fire. The NIST fire models were used to demonstrate how the DuPont Plaza fire developed. Expert judgement was then used to argue that one sprinkler head near the origin of the fire, in a ballroom, would have prevented most of the deaths. Having a computer model to demonstrate quantitatively the effect of a sprinkler head in various situations and various placements in such a building will strengthen the arguments and reduce court costs. [22]

---

[22] It may increase costs for some, such as building owners who should have had them installed. Also, it costs something for the engineering expertise to run the model and testify about it, but that is very small compared to the other costs of litigation.

Estimated Impact -- 10 percent of the once-in-ten year major fire litigation plus 10 percent of annual litigation fees. Annualized, that is 10 percent x $1 Billion x .1, or $10 Million a year plus 10 percent times $200 Million = another $20 Million a year, for a total of $30 Million per year in reduced litigation.[23]

We note a staff comment that engineering models may not be sufficient but can often lower design costs by reducing the amount of full scale testing needed.

4. *Advanced Sprinkler Systems*

Under the baseline CFR five year plan, there are no funds for sprinkler technology development. CFR would continue a low-cost effort extending past work only a small degree. The development job would be left to industry, which has primarily focused on cost-cutting of existing systems and not new technology.

Under an enhanced five-year-plan, CFR would research suppression systems to find the minimum system that can still provide adequate safety. The analogy is between a modern bridge and an old bridge; it took three times as much material to make the old bridge and it is less structurally sound than what can be built today because of improved engineering research and the use of computer models.

Using new technology, CFR might be able to increase efficiency and cost of sprinkler systems by another 20 percent at a conservative estimate. Among the new concepts to be explored, for example, are sprinkler heads that can shoot streams in a selected direction based on sensing where the fire is, rather than spraying equally in all directions at the same time. Such "smart" heads give much more suppression capability for a given amount of water. Even more efficient would be a system where you could

23 The rest of the HAZARD I model and its future developments will increase the impact on litigation, and are computed separately.

detect the size <u>and</u> location of the fire after the automatic suppression system activates. If a flame is detected when very small, a well-aimed water gun would suffice to extinguish it. That also would dramatically reduce water damage.

Estimated Impact – 20 percent savings x $3 Billion = $600 Million per year in reduced costs to industry. Sprinkler technology is an area in which the U.S. can compete favorably with overseas firms. New technology plus resolution of the international standards harmonization problems can contribute to a much greater worldwide market for U.S. firms. Losses also would be decreased by the new system, even more so than with current systems because the fire would be extinguished in a smaller stage and with less water. We estimate another 5 - 10 percent of current industrial losses. Depending on price, these systems could also boost the home sprinkler market by reducing the threat of water damage. However, no dollar estimate is included here for the residential impact.

5. *Sprinkler Reliability*

Sprinkler systems are heading toward being present in virtually all public buildings, buildings with high occupancy rates, and many businesses and storage facilities. Sprinkler systems tend to fail catastrophically. Businesses must depend on the reliability of the sprinkler system, or have redundancy built into passive or other active buildings systems, at greater expense. The costs of structures can be reduced if more is known about reliability and effectiveness tradeoffs; research on sprinkler system reliability tradeoffs would be done as part of the enhanced budget.

Sprinkler systems engineering also needs to consider the arson problem. How can sprinkler systems be disabled, how can they be overwhelmed, and what must they sense and alarm to prevent this? Can multiple simultaneous ignitions be handed? What implications are there for system costs?

Estimated Impact – Previous impact estimates were made with the assumption that the newer systems would be reliable. Also, we have already estimated impacts from better engineering. In that sense, at least part of the impact already has been accounted for, so we are not adding a separate impact estimate here. If the other work was not done and this was, a separate estimate would be justified.

6. *Halon Replacements*

Halon automatic extinguishment systems are in worldwide use to protect equipment from fire in situations where water from sprinkler systems might do costly damage. Included are rooms with expensive electronic equipment such as computers, electronic telephone switching systems, aircraft hangars (where avionics could be damaged by water), Air Force flight lines, museums with fine art, and the Library of Congress.

It is estimated (by DuPont) that there is over $100 Billion currently invested worldwide in halon systems and their agents.[24] The Halon Research Institute estimated that the average halon installation in the U.S. is approximately $500,000. Obviously the investment protected by these systems must be at least several times the cost of the systems, but the investment also is there to prevent discontinuities in operations. The halon systems also help maintain national security and help preserve our national heritage.

Halons have been identified as a major environmental hazard, and must be phased out of worldwide use as rapidly as possible. For some applications, halons will

---

[24] Gann, R.G., J.D. Barnes, S. Davis, J.S. Harris, R.H. Harris, J. T. Herron, B.C. Levin, F.I. Mopsik, K.A. Notarianni, M.R. Nyden, M. Paabo, and R.E. Ricker, "Preliminary Screening Procedures and Criteria for Replacements for Halons 1211 and 1301," National Institute of Standards and Technology, Technical Note 1278, 1990.

be gone in a few years, though their use for fire protection has been allowed to continue under recent legislation while a replacement is sought.

NIST (and the University of New Mexico) has been chairing a technical group that is evaluating alternatives to halons and advising on the enormous cost-benefit tradeoffs among the alternatives. The NIST role is to help identify classes of chemicals that could replace halons in existing systems, develop methods for screening specific chemicals that are developed as replacements, and considering how low a level of ozone depletion must be achieved for a new chemical replacement for halons to be considered satisfactory.

Estimated Impact (Past Studies) -- Choices that allow saving even part of the $100 Billion invested in halon systems by using much of the existing hardware and a new gas would be worth tens of billions of dollars. Helping choose a non-harmful chemical to replace halons has major impact on life on earth, as melodramatic as that may sound. It also is important not to have a "cure" worse than the problem (recall TRIS-treated children's fire resistant sleepwear.)

Under the enhanced five-year plan, expanded uses of the halon replacement would be explored. They would have the advantage over water of using a gas extinguishing agent, which can offer better protection than sprinklers behind partitions that block the water. Also, the non-destructive (no water damage) extinguishment might be preferred to water-based applications, especially in combination with smart detectors.

Estimated Impact (Enhanced Level) -- There will be a major new market for the gas extinguishing system that replaces halons, though possibly offset somewhat by a reduction in the sprinkler systems market. Net: Tens of millions per year ($.01 - .1 Billion). There also will be reduced losses to industry from expanded use of automatic suppression where not presently used: 1 - 5 percent x $4.2 Billion industrial losses per year over present = $40 - 200 Million per year.

C. Building Design and Codes

The advances in fire detection and suppression that were discussed above are part of a much broader CFR strategy to improve the built-in fire safety of buildings. CFR has undertaken a great deal of theoretical research on fires that has led to the creation of an increasingly refined set of models and tradeoffs of building safety features. Costs of fire protection can be reduced, and fire protection made more effective with these models. Less of a safety margin needs to be added to buildings to cover ignorance.

The long-term concept is to feed results of theoretical and laboratory research in an every more capable model of fires in buildings, with specialized modules added to deal with areas such a sprinkler refinements or escape planning.

1. *HAZARD I Computer Models*

"HAZARD I" is a set of computer programs that allow the user to simulate: fire and smoke transport through a building; people behavior and movement; and the effect of smoke and toxic gas on escaping individuals. HAZARD I allows one to study the rate of spread of a fire and build-up of toxic gases as a function of building geometry, contents, ventilation, occupant actions and other factors.

The model quantifies the hazard in a particular situation as a tool for fire protection engineering studies. The model permits options in building design and use to be considered, and to safely trim safety factors and avoid unnecessary redundancy.

HAZARD I at present is useful for examining residential life safety and small structures but not large structures. There are close to 300 copies in use worldwide and that continues to rise, along with knowledge on how to use it. However, only a few anecdotes have been received thus far where the present version has been used for building design or fire investigation, or other practical use. CFR itself probably is still

the major user, and has made a number of contributions with the model as discussed throughout this report. The usage is expected to increase as familiarity with the model's capabilities (and limitations) is better understood, and as the model continues to improve and to be proven.

At enhanced budget levels, HAZARD I would be extended to include:

- larger spaces
- larger, more complex buildings
- built-in suppression (sprinklers)
- HVAC systems
- Evacuation of non-residential buildings

Developing the models further requires testing and research; it is not simply a matter of putting in existing knowledge. Being able to do this could reduce the great expense of fire protection in industrial and commercial buildings.

On the input side, HAZARD II would allow the user to input "his" building in a friendly, rapid manner. A wide range of structures beyond the present simple buildings would be possible. The results for a given fire scenario would be quickly computed. Another use for an enhanced HAZARD II would be to get consistent approval of new building components (their fire safety ratings.) If everyone gets the same results, that could again accelerate introduction of new products, and help determine functional fire safety equivalents. The HAZARD II model could be given to architects who could determine if their designs were satisfactory.

An important complementary development to HAZARD II would be a major new fire test capability to make more reliable translations of bench scale fire tests to full scale effects. For example, being able to test various new coatings for walls in the lab, and then enter the results in HAZARD II, might allow identification of a way to make cheaper walls that would give the same or better performance as present ones.

Use of the HAZARD I and its enhancements also may have a major impact on codes. The models are likely to allow some backing off from current overprotection levels, and to do so by type of occupancy. For example, standards for carpets might be reduced for offices but not for restaurants. The impact of HAZARD I is discussed at the end of the next section.

2. *HAZARD "n"*

At the enhanced budget level, more advanced levels of HAZARD I and II would be developed. This would be a giant step forward in the capability of fire models, with many practical dividends. (This capability may eventually be reached at a slow pace under the zero budget level; the enhanced level would yield more years of usefulness.)

Estimated Impact -- Without further development HAZARD I is estimated to improve efficiency of built-in fire protection in buildings, by 5 - 10 percent. This translates to $1 - 2 Billion based on Meade's estimate of $20B in built-in protection costs today. Another 10 percent reduction or more in the fire protection costs of buildings (.1 x 20 Billion) = $2 Billion per year is possible with HAZARD II. In addition, the enhanced HAZARD I and HAZARD II should reduce code administration costs by 10 - 20 percent, and lead to additional savings in efficiency of fire protection by further reducing overprotection wrought by lack of information in code development.

Yet another use for HAZARD I or II in the future is to generate a data base for various types of buildings, instead of having to research each separately. The fire service could then use the HAZARD type models to do a better job of <u>pre-planning</u>. They could "see" the growth of a fire and explore different approaches to stopping it, ventilating it, and rescue strategies. They also could help intervene in fire safety planning by the building, (e.g., show the owners the potential impact of installing smoke barrier doors.)

Estimated Impact -- 5 percent of commercial losses = $.2 Billion

3. *Fire Safety Evaluation Tools*

In addition to computer models for evaluating fire safety of buildings, CFR has pioneered in the development of simpler tradeoff methodology in which points are awarded for the presence of different safety features. Perhaps the best known application of this approach is in health care institutions.

Health Care -- CFR developed a fire safety evaluation system for health care institutions that was a major breakthrough in making safety tradeoffs easier to consider in light of safety equivalence for these facilities. The system allocates points to different safety features, and allows a variety of choices to be explored in finding a cost-effective approach and/or one that fits the operating needs of the institution. The evaluation system also can be used to provide inputs for the design of sound codes with more options for flexibility. To develop this system, panels of experts met in a series of iterations to evaluate the point-weighting of different safety features individually and in combinations.

Estimated Impact -- Former Secretary of Health and Human Services Joseph Califano credited NIST with saving the health care industry $2 Billion over several years by using the evaluation system. The savings continue to accrue.

The Veterans Administration estimated they saved $150 - 200 Million in construction costs while maintaining the same level of safety.

Massachusetts General Hospital estimated a savings of $1.5 Million in construction plus a huge savings from not having to temporarily close down during renovation, for a total of $68 Million. The model allowed consideration of fire-rated doors with closures vs. other more expensive building features, for example.

Based on these examples, we estimate a minimum annualized savings of $.2 Billion.

Tools for Other Occupancies -- NIST has designed similar fire safety evaluation systems for apartment buildings, board and care facilities, detention and correction facilities, business occupancies.

GSA is using the business occupancy system to evaluate the suitability of rental space. For a variety of reasons, the others are apparently not yet in use much.

Future Impact -- What is the potential here? If the Healthcare industry was saved $0.2 Billion per year, and it spends $10 Billion per year in new hospitals, what is reasonable to estimate for other industries using the same principle? Healthcare buildings comprise only 2 percent of the total construction ($9.5 Billion out of $410 Billion in non-residential buildings in 1988. It is not unreasonable to assume that similar procedures developed with the aid of advanced fire models under the enhanced budget would lead to 1 - 2 percent savings in other industries, as they did in health care. Since not all are equally regulated or given as much attention as health care, we take the lower estimate of 1 percent - $4 Billion.

4. *SFPE Handbook*

Over 50 percent of the Society of Fire Protection Engineers' Handbook is based on CFR work or that of its grantees. This "bible" of fire protection is heavily used in designing building fire protection systems.
Estimated Impact -- Unknown, but large.

5. *Smoke Control in Buildings*

CFR has done much of the engineering research that has turned design of smoke control systems into an engineering discipline rather than depending on rules of thumb. The Smoke Control Handbook published in 1983 by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) is heavily based on CFR research and writings.[25] The handbook now is used throughout industry and around the world.

The impact of this work has been very large. Many of the rules of thumb that had been in use were not valid. Approximately 50 - 80 percent of the "smoke control" systems did not control smoke. Smoke control systems designed more recently are satisfactory. The CFR work not only contributed a theoretical basis for practical design, but sharply improved the capability of many building systems to cope with smoke. Much loss in fires -- especially small fires -- is from smoke damage rather than flames, so this meant a large improvement in loss control.

In addition to improving design, the CFR work has led to a higher degree of confidence in smoke control, and has reduced problems in acceptance testing -- another savings in the process of construction. (Putting in the right size fans and duct work reduce the delay in occupancy, and translate to cash savings for builders.) To cite one example, CFR staff (Klote) knew of one job in Florida that cost $6 Million to design and test because of the inability to pass the acceptance test; he estimated that $300 - 400K would have sufficed with the proper design in the first place.

Smoke control engineering is an example where the CFR increases the design cost and the level of engineering competence needed, but achieves a sharply lower overall cost.

---

[25] John Klote was the principal author.

Estimated Impact -- 50 - 100 percent of the cost of smoke control systems designed the old way, plus reduced liability and reduced damage from smoke. As an interim estimate, we assume 0.5 percent of cost of prevention in buildings, or .005 x $20 Billion = $.1 Billion. The impact on non-residential losses is estimated at two percent, low because most buildings do not have smoke-control systems.

D. Safer Consumer Products

CFR research affects the quality of the products in homes and offices across the United States. By developing tests and criteria for industry-wide standards, CFR allows manufacturers to develop products that can be sold throughout the U.S. (versus having to meet different standards in different states). Products built to the standards and passing accepted flammability tests also have sharply reduced liability exposure.

CFR also influences world standards, and helps make U.S. products more easily sold abroad when tests are consistent. CFR also provides to industry an understanding of the differences and equivalency in tests from other nations.

Much of the work on particular products emerges from fire safety controversies with regard to a particular industry, such as hotels, mass transit, tobacco, or furniture. CFR often has the role of impartial third party. These situations usually cannot be foreseen. They are handled in addition to the five-year plan, and often are paid for largely by other agencies, or special Act of Congress, though some of the seed work (initial consulting) sometimes is done with in-house funds. The following are examples of some major consumer products that CFR has affected, or currently has under study. It is likely that additional work will be done in the future, though it cannot be predicted and is not part of the CFR five-year plan.[26]

---

[26] Some consideration might be given to considering consumer products frequently involved in fire as part of the five-year plan, in cooperation with CPSC.

1. *Upholstered Furniture*

CFR has assisted industry in developing voluntary standards for upholstered furniture -- the UFAC standards. At the time they were being developed in the late 1970s, about 80 percent of new upholstered furniture sampled by CPSC was ignitable by cigarettes. Now approximately 20 percent of new furniture is ignitable.

The agreement on workable voluntary standards gives industry more flexibility. The existence of standards also reduces liability; furniture built to the state-of-the-art standard is more defensible.

This has contributed to the decrease in upholstered furniture fires, casualties, and dollar loss.

Estimated Impact -- Using the average annual drop in losses from upholstered furniture for 1980 to 1984 from John Hall's report [27], the fire problem involving upholstered furniture dropped by 2150 fires, 48 deaths, 133 injuries, and $10.75 Million (1986 dollars) per year. Using $40K per civilian injury and $1.5M per death, that is $5.3M + $72M + $10.8M = $90 Million per year. The impact of the standards increases every year as more and more households get furniture that meets the standards. We will estimate here that the CFR contribution is at the level of the initial savings, and apportion the growth in impact to the other parties who act to sustain the savings. CFR's impact therefore is estimated at the $90 Million level per year. The small additional cost of building in fire safety to furniture has largely been passed on to the consumers, who have a more valuable and safer product.

[27] Op. Cit.

In the future, a database on flammability of materials could help furniture manufacturers speed up their materials selection by not having to do tests, or being able to do smaller tests to validate material/substrate/framework combinations.

2. *Carpets*

NIST testing assisted in the development of carpet standards for the ignition and rapidity of spread of fires. Carpets have become only a minor item first ignited and a minor source of flame spread in commercial and residential fires. The impact is at least tens of millions of dollars. One would need to do a special NFIRS analysis to quantify this further. (It is quite feasible to do.)

3. *Mattresses*

CFR assisted in development of the federal standard for mattress flammability. This has helped reduce fatalities involving mattresses.

Estimated Impact -- Using 1980-1984 as typical, and Hall as the source: The average yearly drop in civilian injuries from mattress fires was 133, deaths 44, and dollar loss $8 Million in 1986 dollars. The equivalent total is: $5.3M + $66M + $8M = $80M per year. Making the same assumption as for upholstered furniture, we estimate the CFR contribution at this savings level from the early years of impact. Liability reduction also is a real savings. We estimate on the order of $10 - 20 Million per year each for mattresses, upholstered furniture and carpets.

4. *Children's Sleepwear*

In 1970 approximately 60 deaths per year involved flammable children's sleepwear. CFR did a special statistical analysis and developed the FFACTS data base that showed the character of the problem. CFR then developed fire tests for the

sleepwear and a method for measuring performance of various materials and garment configurations.

The resulting children's sleepwear standards based on the CFR work virtually eliminated the problem by requiring the sleepwear to be fire-resistant.

Estimated Impact -- Children's sleepwear deaths went from a level of 60 child deaths per year to less than five per year. At $1.5 Million per death, the cost benefit is 55 x 1.5M = $80 Million per year. About half might be claimed for CFR, the rest for other parties who helped promulgate the standard. Yearly impact for CFR: $40 Million.

The sleepwear standard sharply reduced manufacturer's liability exposure. If they still sold the flammable sleepwear, deaths probably would have risen with population increases by about 20 percent, to about 70 deaths per year. Further, serious injuries would number 2 - 4 times the number of deaths; the injuries pose even greater liability than deaths because severely burned children require enormous costs to heal, their psychological damage is so high, and their plight generates great sympathy and anger. Court awards are routinely in the millions of dollars. Thus, 120 - 240 injuries plus 55 deaths is a total of 175 - 300 incidents. If ten percent of the families sue, and 50 percent of the cases yield a substantial judgement against the manufacturer at $1.5 Million, the liability savings would be
.1 x (175 - 300) x .5 x $1.5 Million = $13 - 23 Million per year. Again crediting CFR with half the savings, that is $6 - 12 Million per year. The total cost benefit impact is then approximately $50 Million per year.

5. *"Fire-Safe" Cigarettes*

According to national statistics careless smoking is the leading cause of fire deaths in the United States, second in residential injuries and eighth in residential fires. The

Cigarette Safety Act of 1984 addressed the feasibility of reducing the ignition propensity of cigarettes. CFR received the main research role under the Act.

CFR experimentation found that simply requiring cigarettes to be self-extinguishing would not have a major impact on ignition propensity. Consumer advocates and some in the fire service and health industry had been calling for standards that would have required cigarettes to be self-extinguishing. This CFR finding averted what could have been a counterproductive activity (fires and fire deaths might rise if people think a cigarette is "safe" and it isn't.)

CFR went on to identify cigarette properties that lowered the ignition propensity of cigarettes (at least in a laboratory setting), including smaller circumference, less porous paper, and low packing density. CFR also completed a significant body of research on the chemistry and physics of cigarette-induced smoldering fires.

The development of a standardized ignition propensity test, investigating the commercial feasibility of alternative cigarette designs, and health-related testing were among the tasks largely deferred to the follow-on study now starting.

CFR staff expects that with research continuing over the next three years under contract from the Consumer Products Safety Commission, with funding from the Fire-Safe Cigarette Act of 1990, a suitable ignition propensity test will be developed. It would allow comparisons of experimental and current cigarettes to be made on a reliable basis. This would provide the necessary tool for reliably identifying "fire-safe" cigarettes and comparing various product designs.

If cigarettes with improved fire-safety characteristics can be developed, relying in part on the planned CFR research, there could be a large impact on fire deaths. If a satisfactory solution is not found, the work still will, at a minimum, permit a

determination to be made concerning whether a "fire-safe" cigarette is or isn't practical to achieve, which is the major question to be resolved.

Estimated Impact -- If a "fire-safe" cigarette is developed, the potential impact, based on NFPA estimates, is a 64 percent annual reduction of smoking-related fire deaths from their level in 1984 by 1996, and 42 percent in the cost of fire excluding deaths.[28] Thus, crudely, .42 x $432 Million direct loss) + .42 (4800 injuries x $40,000 per injury) + .64 (1840 deaths x $1.5M per death) = $181M + $80M + $1766M = $2 Billion per year cost-benefit savings from the 1986 levels of losses if per capita smoking stayed the same.

Since those NFPA estimates were made, fire deaths, injuries, and dollar loss from careless smoking have declined significantly. Preliminary estimates for 1989 from NFIRS and NFPA data suggest that smoking-related fire deaths have dropped to about the 1000 - 1200 level. The reduction in cost-benefit therefore might be closer to $1 Billion per year rather than $2 Billion, for the near term, and lower in the out years, but still a large savings if the problem can be solved completely. The absolute savings would vary depending on the number of smokers, the increase of working smoke detectors, and the spread of effective public education. The order of magnitude of potential benefit, however, is $100 Million property loss reduction and $1 Billion cost-benefit value in lives and injuries saved per year. Determining how realistic these estimates are must await the results of the further research and developmental work described above. Eventually, somewhere in the period from 5 to 20 years from now, the cigarette-related fire losses should be down sharply through a combination of the further spread of smolder-resistant

---

[28] Interpretation of data in "Expected Changes in Fire Damages from Reducing Cigarette Ignition Propensity," Report 5, Technical Study Group, Cigarette Safety Act of 1984, October 1987, John Hall, Jr., NFPA.

mattresses and upholstered furniture, public education, and built-in fire protection, all of which CFR has already contributed to, as credited elsewhere.[29]

6. *Woodstoves*

CFR helped develop safe installation procedures for modern woodstoves. Had these not been developed, the industry might not have survived at its current level. (Improper installation is the leading cause of large dollar loss fires involving woodstoves.)

Estimated Impact -- Multi-millions of industry sales plus large losses averted. Woodstoves and their chimneys accounted for over $120 Million in losses per year from 1980 - 1986. Misinstallations on a larger scale could have doubled these losses. CFR's role is estimated at 20 percent of this savings (versus the industry and consumer groups giving out the information on safe installation.) Thus, as a rough estimate the CFR impact is on the order of $25 Million per year, plus some fraction of the industry's sales.

7. *Designer Plastics*

Industry has already learned enough about polymers to be able to design a plastic today with particular physical or mechanical properties. These plastics then have to be tested for their fire properties, such as rate of heat release and toxicity. If the results are not satisfactory, the design has to be cycled again. *Estimated Impact* -- The test savings could be on the order of $1 - 10 Million (or is this low?)

---

[29] One has to be careful not to double count benefits; the total saving estimate should not sum to more than the total size of the problem. However, since one cannot be sure which of the several strategies to future fire cost reductions will pan out, one does not want to underestimate the potential of these strategies individually, either.

It is desired to develop a "cookbook" to be able to specify the fire properties as well as physical and mechanical properties of the plastics at the same time. This is planned under the enhanced budget level. It would help ensure that fire properties are indeed considered and would reduce costs of having to iterate the designs and test each. This could ultimately reduce flashover times and reduce the death rate per fire.

Estimated Impact – Since plastics are thought to be a major contributor to the shorter flashover times and increased losses per fire, this is an area of potential major impact. On the order of 100 - 500 lives per year and $.1 - .5 Billion reduction in fire losses are a ballpark estimate.[30]

8. *Fire Modeling of Product Involvement*

The Hazard I computer fire model (discussed above) can be used to evaluate the relative fire safety of different products or materials. This has uses in reducing product liability and in product design.

The model can be used by industry to determine whether their product made a substantial contribution to the fuel and to the development of a fire, and hence in the outcome of the fire. The model can "reproduce" the fire and show what would have occurred if the product in question were not there or had different burning properties. In today's litigious climate, virtually every product that burned in a fire might be targeted by lawyers of the plaintiff. The model should help prevent suits as well as help pinpoint situations where a product truly did make the difference.

On the other hand, the HAZARD I model might help show that, say, wood paneling or vertical carpeting added to the rapid spread of a fire, which might increase

---

[30] CFR research into the role plastics play in fire development, perhaps with the aid of HAZARD I, might refine this estimate.

the case against the building management. Typically, however, this side is easier to argue without the model than is the defense side. But it could be worth much to the plaintiff in reaching settlement quicker or reducing expert witness costs.

Estimated Impact -- Property loss suits can range from $100,000 to over $100 Million. The Norwest Bank fire in Minneapolis suit was for $200 Million; the Interstate Bank of California fire suit will probably top a billion dollars.) Companies whose products were incidental to a household fire that killed or injured someone often settle for $50,000 - $150,000 just to avoid legal costs of a full suit. (We know of one case where a Fortune 500 company settled for $150,000 because their microwave was present, even though no one asserted it caused the fire, and it was not at the point of origin.)

One or two uses of the module in major lawsuits and 10 - 20 uses in smaller suits could easily save (1 - 2) x ($4 Million) + (10 - 20) x ($150,000) = $6M - $11M. A once-in-ten-year fire could add $50 - 100 Million in product liability suits, or another $4 - 10 Million amortized per year. So the combined effect might be on the order of $10 - 20 Million per year. As the model is enhanced, and confidence is increased in its use, the range of application should mushroom; we estimate a tripling of the impact here.

The HAZARD I model can also be used to see how far a product's performance (and hence design) has to change to make a difference. The model can consider ignitability, burning rate/fire spread, smoke generation and toxicity. Under the enhanced budget level these capabilities will be sharpened and data bases developed to facilitate their use. They also can be used to help sell a product; for example, the model can show that fiberglass ticking on mattresses makes a major difference in hotel/motel fires. This can help both manufacturer and customer.

A special version of HAZARD I called "CPSC HAZ I" has been developed for CPSC or others to explore the potential for using such a model to examine differences in mattresses and upholstered furniture.

Estimated Impact -- The use of HAZARD I for product design affects industries with $80 Billions in sales. A combination of assisting in designing, reducing losses and liability from the basic design aspect is probably potentially worth on the order of one or two percent of sales -- on the order of $.8 - 1.6 Billion.

E. Major Fire Investigations

CFR is frequently consulted on to assist in the investigation of major fires. These often gain headlines, and shape fire protection policy. Some examples follow.

1. *DuPont Plaza Fire*

The CFR analysis of the DuPont Plaza hotel fire in Puerto Rico was widely publicized in the fire service and made into a presentation for a committee of Congress that investigated what should be done in its aftermath. The CFR analysis showed the importance that a single sprinkler head could have played in that fire, and the influence of other hotel safety features. The analysis became a prime stimulus for what has become the Hotel and Motel Fire Safety Act of 1990. It also provided a major impetus to the hotel industry to accelerate the introduction of sprinklers in hotels. As a result, hotel fire deaths have dropped more sharply than any other class of fire deaths, down almost 70 percent from where they were a decade ago. Hotels with sprinklers have been favored for many types of conventions and individual travel, and have received insurance breaks. The effect has been a plus for the hotel industry despite initial fears.

Estimated Impact -- One-two year speed up in sprinklering of half the hotels and motels in the United States. Major revision to building codes and sprinkler industry in Puerto Rico. About 50 hotel fire deaths per year fewer than at the start of the 1980s. The number of reported hotel fires also have decreased, but hotel dollar loss has actually been increasing, along with the number of hotel rooms. Without sprinklers the dollar losses would undoubtedly be higher, but it is unclear by how much. Based on the cost

benefit valuation of the deaths averted, we estimate CFR share as 10 deaths fewer or $15 Million per year. (This can be taken to include at least some of the fire loss reduction that must have occurred, too.)

2. *New York City Social Club Fire*

CFR has investigated and modeled the fire at the Happy Land dance club that killed 87 in New York City in March 1990. A major issue in this fire was the need for the low-income Hispanic community to have affordable social clubs on one hand and the expense of maintaining clubs up to code in low-income areas on the other. The New York City Fire Department asked CFR to recommend what could be done realistically to prevent such fires. CFR analysis has shown that modest changes to the clubs can sharply reduce their lethality, even without sprinklering.

Estimated Impact -- To be determined, pending New York City actions.

F. Firefighting Tactics and Technology

Almost no CFR research has gone into fire service firefighting technology. This is because the Fire Act, PL 93 - 498, assigned primary responsibility for research on firefighting technology to the United States Fire Administration. Nevertheless, a few important contributions in firefighting have been made by CFR:

1. *Compressed Air Foam*

There are many chemical additives that contribute to the fire suppression effectiveness of water, including the latest, most promising foam technology, compressed air foam, a "surfactant." Something that looks like a white shaving cream mixture is added to the water supply, and the resulting foam mix sticks to surfaces (and hence is a "surfactant").

There is a large potential for improving wildland firefighting with such a surfactant. It can be used to coat trees or structures in the path of a wildfire, protecting them temporarily from a rapidly moving wildlands fire. This can be used to form a fire break, or to protect things of value.

The surfactant foam functions much better than water because it "stays wet" longer, and is more visible than water, hence preventing duplication of efforts by hard-pressed fire crews who cannot always tell what has already been wetted down. It also tends to stay in place longer.

Because this foam is a "low energy" foam, a lot of foam can be delivered from a small, lightweight container. It can be loaded into a backpack that one man can handle. A pick-up truck with the foam could have the same suppression effectiveness as a large engine truck today. The foam is judged 20 times more effective than water.

NIST is going to test the relative improvements in using this foam versus water. If the promise holds up and findings are widely disseminated, there will be a sharp improvement in the cost-effectiveness of wildland firefighting. Either a larger number of firefighting pick-up trucks can be purchased for the same current budget used for engines, or the costs of the firefighting apparatus can be sharply reduced; 50 - 80 percent reductions in costs (or a comparable increase in capability) are possible if this technology proves out.

Urban-wildland interfaces are an ideal environment for the use of this technology, where a relatively small number of homes needs to be protected in large wooded areas. This situation is a growing concern of the Forest Service and other fire protection authorities, and can be given a material boost by this technology. It also can help preserve our irreplaceable national parks.

Estimated Impact -- We estimate approximately 1000 wildland fire vehicles valued at $200,000 each and with a 20 yr. life = $10M per year amortized annual cost[31] .A 50 - 80 percent reduction in this cost would yield (.5 - .8) x $10M = $5 - 8 Million per year in savings in new government vehicle costs. In addition, there would be a decrease in manpower needed, plus reduced wildlands losses and buildings. Furthermore, a new product would be developed with export market opportunities. Depending on the change in performance, this could have huge impacts on reducing cost of fighting wildfires -- tens to hundreds of millions of savings are at stake. CFR would have a share of that savings.

2. *Firefighting Demand Model*

About two decades of work have gone into the development of a "fire demand model," with much of the work done by Mission Research Corporation under contract to NIST. This model allows analyzing the effects of a hose stream on a compartment fire -- a necessary tool to exploring ways to improve the efficiency of firefighting, still largely an art. For example, there is controversy over when to ventilate and where to ventilate a building fire. This model can help settle those controversies, improving the effectiveness of firefighting operations. It also can improve safety for the firefighters, many of whom are injured in the course of doing ventilation and some as a result of self-venting of fires. Firefighter injuries not only are expensive ($250,000 - 500,000 for medical care and pensions for a serious injury) but are leading to litigation in the millions of dollars per incident. Preventing injuries means significant savings for cities.

Estimated Impact -- Knowledge gained from the model on improving ventilation and other aspects of firefighting could improve firefighting efficiency and reduce losses by 1 - 5 percent x $8 Billion fire losses = .08 - .4 Billion.

---

[31] An estimate from the Forest Service is still pending.

A successful model can not only help fire department training, but can also be the nucleus of a new commercial software package that potentially could be used on every fire vehicle in the world. As city budgets in the U.S. and worldwide generally are declining for firefighting staff, any concepts that help make do with less staff are highly important.

3. *Nozzle Analysis*

NIST research also has helped nozzle manufacturers understand just what their product does in fires. (Cost impact unevaluated.)

4. *Firefighter Protective Outfits*

CFR undertook tests of the thermal performance of firefighter's turnout gear, to help develop better protection.

Estimated Impact -- Firefighter injuries associated with fire calls number on the order of 50,000 per year. If firefighter injuries are evaluated at the civilian cost of $40,000 per injury, the total cost is $2 Billion. Only a fraction of the injuries are thermal burns, and some injuries such as heat exhaustion seem to be related to wearing the new outfits. Nevertheless, there is a net advantage, especially in averting the more severe burn injuries, the greatest concern of the firefighters. Impacting any fraction of the injuries -- even 1 percent -- reduces the losses by hundreds of millions of dollars.

5. *Navy Firefighter Trainer*

The Navy Equipment Training Center developed a propane-fired live simulator of fires whereby a firefighting crew could spray water on real flames in the simulator, and have the flames go down or get larger depending on how well they fought the fire. This is a safe way to give realistic training to many sailors.

CFR has repeatedly consulted on debugging the simulator and assisting in much of its engineering. This has speeded up its development to a satisfactory level by 1 - 2 years. ***Estimated Impact*** -- Millions in training costs.

6. *Smoke Generation Product*

A product commonly used to simulate smoke in Navy firefighter drills cost $75 per gallon. NIST tested an alternative product that cost $15 per gallon, and showed that it was perfectly adequate. ***Estimated Impact*** -- $60 per gallon used; hundreds of thousands of dollars(?) per year.

7. *Submarine Firefighting Training Simulation*

The Navy was concerned about an insulation problem on a new high-tech simulator. CFR showed that the problem was poor installation of the insulation, but that the material used was satisfactory. This allowed a fix to be made and avoided a more costly re-engineering program hundreds of thousands of dollars saved, plus secondary cost benefits on having the simulator operational a year earlier; that, in turn, has a cascade effect on the quality of training and potential loss aversion. CFR's impact often is to provide the nail in the shoe of the horse that makes the critical difference in the battle. A small contributor's impact, as here, may have a very large impact downstream.

8. *Fire Investigation Handbook*

In 1980 the CFR issued a *Handbook of Fire Investigation.* It described how to do a fire investigation and what you learned from the various steps. It is now out of print, and needs to be updated to reflect new research findings and new tools available. It has been a "check-rated best buy." Impact is unknown, but it is an excellent guide for fire investigation, and one of few (if any others) that is written by scientists.

9. *Advanced Suppressant Delivery Technology*

Under the current budget, CFR would be making a few contributions to manual firefighting from ad hoc studies, but not attacking the mainstream technologies.

Under an enhanced budget, CFR would consider advanced suppressants and advanced suppressant delivery modes to make firefighting more efficient and effective.

Estimated Impact -- Any advances over the current approach of delivering water-through-a-hose by judgement and ventilation by judgement, could have huge paybacks in labor saving and/or reduced losses. If the efficiency of manual firefighting were increased by even one percent, the potential savings would be .01 x \$9.6 Billion = \$ .1 Billion for paid firefighting costs and .01 x \$30 Billion = \$ .3 Billion for volunteer conversion costs, or \$0.4B per year. If the efficiency improved by five percent instead of one percent, there would be \$2 Billion per year. Reduction in losses would be in addition to these labor savings.

G. *Flammability and Toxicity Tests*

One of CFR's major contributions over the years has been the development of flammability and combustion toxicity tests. This is a basic part of the CFR charter.

1. *Efficient Testing Methodology*

Testing products to determine if they meet standards costs industry in the hundreds of millions of dollars each year. NIST has made a major contribution to the development of economical, realistic test methodologies. The use of a small sample of material with superimposed radiant heat has been shown to be a good predictor of full scale tests for several types of products. (Two examples are discussed below.) This work

not only reduces costs of testing to industry, but also reduces the degree of hazard of the product. (This aspect was noted previously in the discussion of products.)

Carpeting -- NIST developed the "pill test" and the flooring radiant test. Most carpets now pass the tests, and one does not have to be concerned about flame spread via carpets, as was once the case.

Insulation -- During the 1970s energy crisis, insulation added to attics to reduce heat loss often posed a fire risk. There were many fires where flammable insulation ignited, or insulation retained heat of lighting fixtures and caused other materials to ignite. NIST devised a radiant panel test for this insulation, and also a recessed lighting fixture test.

CFR has strived over the years to improve the validity of fire tests, and at the same time try to simplify them and reduce their costs. Good tests increase assurance of safety as well as reduce costs. Some tests have been shown to be meaningless -- not only a waste of resources but dangerous. The more streamlined the testing, the easier to market it and the more likely there will be consistency nationally and internationally.

Reducing the variety and complexity of tests also reduces the costs of keeping up with them, which inhibits competition by smaller companies. And it increases the ability to compete internationally.

Estimated Impact -- Millions per year in test savings.

2. *Cone Calorimeter*

CFR developed the "cone calorimeter," a major breakthrough in instrumentation for fire testing. It accurately measures heat given off by burning a sample of a material (or whatever.) Fire test standards in Europe are expected to change in 1992, and they

have had early awareness of the importance of the CFR work. This device is the front runner for becoming the world standard for fire testing. If so, it gives the U.S. a large leg up in the availability of the test equipment and the knowledge of its operation.

However, ASTM has not adopted the cone calorimeter, and is further from doing so than the Europeans. The total impact of the CFR work for the U.S. depends on whether CFR is successful in getting ASTM to join the bandwagon early. The opportunity is to lock in the U.S. fire test technology. (The danger is that Europe will do it and we won't.)[32]

Estimated Impact – Part of the impact of test methodology is reflected in the discussion of consumer products (Section D above). (Is there a way to estimate the value of having better test methods per se? Are they cheaper replacements of previous technology? Or is their cost-benefit best reflected in what they are used to develop?) Also, is there a new market for cone calorimeter-based tests, or does that displace an equal market?) No separate estimate has been made of their impact beyond the contribution to other areas, but it is thought that they do have impact.

3. *Modernization of Fire Test Methods*

Fire test methods are refined over time, but breakthroughs require concentrated efforts such as would be available under the CFR enhanced Five-year Plan. These are fundamental tools underlying much of the fire-related research and development in industry, and are a critical and unique contribution that CFR can make.

Estimated Impact – $.1 - 1 Billion per year, partly from more efficient testing, but more from the improvements in materials that can result from better tests and standards.

---

32 One problem noted by CFR staff here was the lack of travel money to provide sustained input to ASTM and codes standards committee deliberations.

To the extent that U.S. tests become worldwide standards, there can be impacts on new markets. Tests and Standards is a key technology area for the U. S. to be in the forefront.

4. *Inhalation Toxicity*

CFR has long undertaken research on the inhalation toxicity of the products of combustion. How fast do gases in a fire disorient, injure or kill? What is the relative toxicity of different combustion gases? Are the differences significant? How do you measure toxicity in meaningful terms? What are the implications of all this for product design? Furnishings selection and interior decoration?

One of the largest contributions of the toxicity research was to find that the toxicity of a combination of gases was greater than the toxicity of the gases individually; there are negative synergistic effects. This sharply affected virtually all design discussions and safety limits involving combustion toxicity.

An extension of this work led to the finding that certain additives (e.g., copper) to flexible polyurethane foam could reduce its toxicity. This holds the potential for at least slowing or possibly reversing the increasing deadliness of today's fires in terms of deaths per fire.

Estimated Impact -- We need a better understanding of the likely use by industry, and magnitude of the effect to make a good estimate here. Nevertheless, as an interim estimate of the range, we note that 80 percent of people who die in fires do so from combustion gases, and toxicity of the household environment, where people most often die in fires, is thought to have increased because of plastics. The potential impact thus is very large -- hundreds to thousands of lives per year. The cost-benefit range is thus (100 - 1000) x \$1.5 Million = \$.15 - 1.5 Billion+, plus injuries and a reduction in litigation.

CFR has been working on how to use toxicity data in hazard calculations -- what data to collect, how to collect it, and how to use it. This is the first time this can be done with confidence. It opens up the possibility of materials development to be done without fear of toxicity changes. It also frees up the use of some current materials, which permits a wider choice for design, and use of less costly materials for carpets, furniture, and other materials. For example, it affects whether nylon and teflon-coated carpets would be acceptable.

Under the base plan, CFR has been developing a measurement method for toxicity of materials that will reduce by two-thirds the current $6 - 10K spent per test -- a major saving for industry required to demonstrate that their products are not toxic. CFR has shown that the data need only be accurate to a factor of 3 to determine whether there would be a significant change in toxicity levels.

Another major finding has been that post-flashover carbon monoxide levels are largely independent of the fuels burning. This greatly simplifies toxicity modeling of the post-flashover stage.

A toxicity module is being developed for HAZARD I, that will add another dimension to evaluating various product designs, and assessing the impact of building contents on the deadliness of fires pre-flashover (the majority of fires.)

CFR work on toxicity of various materials in fires helped prevent needless regulations, and stopped what might have been a stampede of states to test consumer products for toxicity without having a sound basis for doing so.

Estimated Impact -- This work has prevented an adverse impact on the furniture and textiles industry that is in tens of millions of dollars. The long-term impact if the work continues as part of the HAZARD models and on its own is likely to be in hundreds of millions in freeing designers, reducing losses and testing costs.

H. Transportation Safety

CFR has made major contributions to improving the safety of public transportation. This increases life safety and reduces liability.

1. *Air Safety*

CFR helped the FAA develop an approach to selecting materials for seats and cabin linings on commercial aircraft. CFR also helped model fires in cabins.

Fires in aircraft cabins usually start from a crash or from a problem outside the cabin (cargo fire, electrical system fire, etc.). The cabin contents therefore influence more the spread of a fire than its start.

Fires are thought to contribute to the death of half the people in survivable crashes. Two recent crashes, one in Dallas, Texas, and the other Sioux City, Iowa, were thought to have 50 - 100 less fatalities because of the improved fire safety of materials in the cabins.

CFR also has modeled smoke movement in aircraft fires. This contributes to the design of aircraft. It was thought that there probably was no major change as a result of this work, though it may help confirm the soundness of existing approaches.

Estimated Impact -- Helping to avert or reduce consequences of a serious aircraft fire once every two years would save 20 - 50 people per year and halve the liability in perhaps 100 suits. On a per year basis, the cost-benefit for lives saved would be (10 - 25 deaths per year averted x $1.5M) = $15 - 40 Million. For liability averted, the cost-benefit savings would be .5 (100 liability cases) x $2M payout per suit = $100 Million. That is a total benefit of $115 - 140 Million per year.

2. *Mass Transit*

The flammability of seats on mass transit buses and metro systems has also been studied by CFR. Another special study was made of the flammability of school bus seats, following a traffic accident in which 27 schoolchildren died from a crash and the ensuing fire on their bus. ***Estimated Impact*** – Undetermined.

I. Ad Hoc Consulting

One of the major unsung services of the CFR staff is ad hoc consulting. It does not appear on five-year-plans, it is rarely included in summaries of achievements, but it is one of the most important year-in and year-out contributions of the CFR staff as a public servant.

Typically, the consulting proceeds as follows: a senior CFR staff member is routed a telephone call first received by the secretaries in the CFR front office. The inquirer, who may be from industry, another government agency, a law firm, or an academic, wants the solution to a fire protection problem, and has turned to CFR as a last resort after calling several other places (10 - 15 previous calls are not uncommon.) Sometimes calls come directly to a well-known CFR staffer. CFR staff seem to pride themselves on not giving people the bureaucratic runaround, but rather trying to provide final answers one way or another. [CFR is an exemplary group with respect to that helpful attitude - author.]

The CFR staffer typically spends five minutes to an hour giving a verbal response, sometimes with callbacks to elaborate. The caller may receive an answer directly, or be referred to another expert, a testing lab, technical reports, or to the CFR Reference Center (which itself is another major starting point for callers.)

Since most of the consulting queries to staffers other than the reference center are "bootleg" -- done without budget, in addition to normal duties -- they rarely are documented, and hence are virtually invisible, and not given much acknowledgement. Most of the staff who were interviewed for this study received enough calls to occupy 10 - 20 percent of their time in addition to their assigned projects. The percentage goes up further if talks and "consulting" contributions to various standards groups and professional associations are included. A few of the outside queries led to a month of effort.

The impact of the CFR consulting is somewhat hard to grasp; within the scope of this study we queried only the CFR staffer and not the "client."[33] Nevertheless, the cumulative impact seems very large. By itself it could justify at least 25 - 50 percent of the CFR budget in terms of economic value to the callers, at an expenditure of only 10 - 20 percent of a 40-hour work week.

My impression is that much of this service is provided above the 40 hour work week, and is performed enthusiastically because of the practical nature of the queries, the interaction with real world users of research, the feeling of fulfilling an obligation to the taxpayers, and perhaps some teaching instinct among the CFR researchers.

Some of the ad hoc work is expected, and has been mentioned in previous sections; e.g., the support of major fire investigations. A few of the ad hoc queries have led to full-blown projects, which also were discussed above. In the sections below we give a flavor of the nature and volume of the requests based on interviews with the staff most frequently called. Sample queries are grouped below by user classes.

---

[33] A "client" survey would shed more light on the value of this consulting service. We are highly conservative throughout this report in evaluating impacts.

1. *Attorneys*

Usually the attorneys who call are active in litigation. Typically, they ask about the state-of-the-art of some technology, existing standards, types of testing, what research should be done for a particular case's scenario, what might have happened to explain a particular scenario, or who might serve as a technical consultant. CFR rarely participates directly in a case; other than general advice, the callers usually are referred to outside experts. Several CFR alumni serve this role, another way CFR expertise is disseminated.

One example of a query by attorneys: an expensive boat experienced a fire and the fire alarm on board did not go off; what were the standards for such alarms, why might the alarm not have gone off?

Apparel flammability is a frequent subject of litigation. Another is the presence or absence of detectors. The detector questions often revolve around whether a particular detector failed to operate, or would a detector have made a difference in the situation?

While a small number of law suits may be tolerable, it is conceivable that detector manufacturers will go out of business -- or double the price of detectors -- if enough court decisions go against them. Improving detector reliability and avoiding spurious law suits are important for the survival of this technology and the saving of lives. Market share also could be lost to foreign suppliers if domestic suppliers suffer high litigation losses. Similar situations exist for other industries whose products are claimed to have started fires.

Estimated Impact -- Some fraction of the $3.5 Billion in product litigation, where the technical information is crucial. Assuming 1 percent impact, the savings would be on the order of $35 Million per year. In addition, hundreds of millions of dollars in

potential sales are preserved if CFR helps save industry from spurious litigation. CFR also may help keep dangerous products off the market through consulting on behalf of the plaintiffs.

2. *Cities and States*

Local government and state government frequently consult CFR on the soundness of proposed ordinances or legislation, and the existence of similar ordinances or legislation. CFR advice not only helps shape new legislation but also contributes to stopping impractical legislation, where science and technology do not yet exist to implement the wishes of legislators.

Estimated Impact -- In addition to the specific examples credited elsewhere we estimate that the impact of state budgets on industry and averting poor legislation is in the hundreds of millions of dollars (e.g., "toxicity levels" for plastic products.)

One specific area of activity for the states has been the degree to which the California 133 Furniture Standard can be relaxed without impacting safety. CFR was asked to validate the California test, driven in part by state-level activity of the IAFF to improve the safety of upholstered furniture (and lessen its hazard to firefighters.) CFR examined the validity of the test, and the range of conditions it represented (e.g., how good did it predict resistance to large flaming ignitions or arson?) The goal of the legislation was to prevent or slow flashover from being reached in commercial and industrial settings. As a result of the CFR work, Illinois and Massachusetts adopted variations on the California 133 test. This standard may in the future "go national."

Having tighter furniture standards reduces ignitions, spread, flashover, and toxicity. The standards make a real impact on everything from hotel lobbies to nursing home furnishings to public assembly and institutions.

Estimated Impact -- Improved furniture flammability standards could reduce non-residential structural fire losses by a roughly estimated 5 - 10 percent x 4.2 Billion = .1 - .4 Billion per year. Further, liability would be sharply reduced, both from fewer losses and being able to point to following standards. The estimated liability savings in a Dupont Plaza fire could be $100 Million (10 percent of the total suits) once in ten years, and about as much in other major suits (e.g., the Interstate Bank Building fire in Los Angeles) or $20 Million per year total liability savings. This liability savings was previously discussed under the use of HAZARD I for product safety analysis, and will not be double counted here.

Continuing with examples of assistance to states, the State of Wisconsin and others consulted CFR about a false advertising ordinance regarding heat detectors; salesmen had been using scare tactics to get people to sign up for inappropriate and expensive detectors.

In another case, advice to the Virginia Center for Innovative Technology stopped a grant about to be given for an old, unfruitful idea for building a smoke detector. (Tens of thousands of research dollars were saved, which took CFR less than an hour to handle.)

As examples of requests from cities, the Los Angeles Fire Marshal requested CFR assistance in the aftermath of a subway tunnel fire. CFR undertook 4 weeks of consulting and testing. The estimated value to Los Angeles was at least $20,000, just in consulting costs, let alone the impact of the consulting.

Many communities (about 24 or so) have asked CFR to provide wording for residential sprinkler ordinances, or to provide convincing arguments for such ordinances.

New York City received consulting on protecting coin booths in the subways from arson attacks.

CFR advised local communities on the toxicity of local land fills where polystyrene was burning. Averting an evacuation of citizens, or preventing the unnecessary closing of a land fill saves millions to tens of millions of dollars. Averting a catastrophe from air pollution is hundreds of millions to billions in impact, depending on the number of people involved. EPA would normally be consulted in these situations, but CFR has assisted, and even occasional impacts of this nature would be enormous.

3. *Federal Agencies*

CFR gets a wide variety of requests from federal agencies. The following are examples of the topics on which CFR is consulted, and the agencies making the requests:

Treasury Department -- CFR advised on appropriate fire alarm system. (Many agencies seek help on fire protection engineering for their own facilities.)

Federal Trade Commission -- CFR helped eliminate and counter false advertising of heat detectors.

Army Corp of Engineers -- CFR helped them improve their fire testing capabilities.

Mineral Management Service, Department of the Interior -- CFR further developed the concept of burning up oil spills on water. The technique was used to get rid of part of the Exxon spill near Valdez, Alaska. The tradeoff was the nature of oil pollution versus air pollution. The technical question was how much of the oil will burn; and what might happen if it burned accidentally. The procedure seems most appropriate for remote places.

Estimated Impact -- Helping reduce damage from oil spills is enormously valuable. If this procedure is used even very selectively, the impacts would probably be in the hundreds of millions of dollars.

Bureau of Mines -- CFR helped defend the Bureau in the 1970s Sunshine Mine lawsuit; this saved tens of millions of public dollars.

Armed Forces -- CFR advised on tolerable levels of human exposure to CO_2. By predicting the effects of different CO_2 levels on human performance, exposure limits were set to allow adequate escape times. This information was used in the design of military equipment.

Estimated Impact -- Affects design of multi-million dollar equipment and materials purchases.

4. *Fire Service*

Many inquiries are received for assistance in investigating significant fires, ranging from major incidents such as the New York City Happyland nightclub fire, the DuPont Plaza hotel fire, the Los Angeles First Interstate Bank fire, the Johnson City, Tennessee elderly residence fire, a three-firefighter fatality fire in an Oklahoma restaurant fire, and an Annapolis house fire.

The requests may involve explaining how a fire developed, whether it was arson or not, and even an occasional murder investigation. *Estimated Impact* -- Essentially accounted for in other estimates.

5. *Private Industry*

CFR receives inquiries from industry on all CFR's major lines of expertise: fire modeling, toxicity, flammability testing, smoke control, detectors, sprinklers, etc.

One class of queries is to discuss ideas for new products -- whether they are likely to work, how they should be tested, whether tried before, what is similar on the market, what is the process for UL or other formal testing, what is the compatibility with standards and how to make the product safer.

By giving such advice, CFR saved one small company about one year in development time for a smoke detector based on a highly promising adoption of an older technology involving detection of CO_2. The staff explained the steps the company needed to take to support their claim. CFR advised the company on necessary tests and volunteered to incorporate the new device in upcoming full-scale fire tests. The new detector potentially has much greater accuracy than current detectors. It may lead to a multi-million dollar market here and overseas.

Estimated Impact -- Short-term savings to the company: at least $100,000; $1M - $10M+ if the idea proves fruitful.

In another case of ad hoc consulting on detector technology, CFR staff helped abort a development thrust that was likely not to have been promising, probably saving the company involved a large loss. (Estimated in hundreds of thousands of dollars.)

CFR saved another company millions of dollars that would have been invested in a fire retardant for cellulosic products that was on the verge of being marketed. The CFR staff showed the company that the idea was not proprietary and could not be protected. Even worse, this particular retardant had an adverse chemical reaction with the product it was intended to make safe.

Industry (and other government agencies) also come to CFR to identify equipment for fire labs and learn about CFR's capabilities.

Questions regarding the flammability of various products constitute a major subset of ad hoc calls to CFR -- about 200 per year. For childrens' sleepwear, manufacturers still call to get help on how to comply with flammability standards. They are often referred to CPSC, too. (Some callers are customers, or mothers in the general public, looking for advice.)

Industry calls to ask about proper protective clothing; power companies are a common "client" on this subject.

Manufacturers of furniture call to ask about the kinds of materials they have to use to pass UFAC voluntary tests, and to inquire about conformance with California Standard 133 and its variations in other states.

Interior designers sometimes call to ask about choice of materials viz a viz building codes.

CFR advises some firms about the fire safety of their plants.

CFR advised a materials manufacturer on the subject of aircraft fires, including FAA regulations and testing laboratory contact.

CFR gets about one request per day to help interpret fire test results, or to give advice on testing methodology, such as use of the cone calorimeter.

About four to six times a year, calls come in to assist with the design of smoke control systems, and the use of the CFR-developed methodology. The firms involved go away with added capability in state-of-the-art design, which helps them and helps in fire

safety. The value of the training itself is estimated to be on the order of $20 - 30K. (Typically about 7 calls are involved of 5 - 20 minute duration each. This works out to 20 - 40 calls per year; the value is approximately $500 - 1000 per call, consistent with other estimates here.) ***Estimated Impact*** -- 100 - 200 @ $500 = $50,000 - 100,000 per year.

6. *Researchers/Universities*

Of course there is a large amount of CFR interaction with researchers in universities and the private sector. Part of this flow is through the extramural grant program. Occasionally the day to day consulting calls from universities involve practical problems; e.g., Penn State inquired about the toxicity of burning polyethylene mixed with wood chips (a potential product.)

Some consulting calls from researchers are to obtain help in interpreting the accuracy and sensitivity of fire modeling results, and how to use the models.

7. *Computer Models*

One sub-class of CFR ad hoc consulting is to provide fire models and advise on their use. CFR computerized fire models were provided at no cost to 100 - 200 people via the Society of Fire Prevention Engineers. People sent in disks that were loaded with the program.

To provide updates on the computer programs and a wider range of models without being labor intensive, a computer "Bulletin Board" was created in 1987 by a CFR staffer. Callers just pay for their telephone call; there is no charge for using the system. The Bulletin Board contains all CFR fire models, bibliography information from FIREDOC, CFR's seminar schedule, and CFR research highlights.

There have been 8000 contacts from over 1000 different people in industry, fire service, and other sectors. About 10 calls per day are received.

Estimated Impact -- By one method, we estimate $50 per contact x 8000 = $400,000. Alternatively, with the transference of models to many, the value per person has been $500 - 1000, or 500,000 - $1 Million. At present, at 10 calls/day, the value is $50/call x 10 calls x 200 = $100,000 per year. All told the estimated impact is about $100-300,000 per year. This does not count the unknown occasional "hit" where someone uses the information obtained to help their organization save hundreds of thousands or millions by a better design.[34]

8. *Professional Groups*

The CFR has a major impact on formulation of codes and standards not only through its research findings, but also through the time spent by CFR staff on committees. (Some CFR staff feel that an enhanced travel budget would permit an even larger impact on standards). And of course CFR disseminates its findings through talks at a wide variety of conferences and in-house seminars.

Some CFR staff spend major portions of their time on code work. One staffer (Bud Nelson) recently received the highest award possible from NFPA for his enormous contribution to many code committees. He estimated this took ten hours per week average year-round. Another staffer (Kay Villa) estimated about five hours per week year-round for NFPA, ISO, and ASTM committees. Often CFR is the quantitative source on the committee. The contribution is not just the sheer time; the committee members found ideas from throughout CFR.

---

[34] CFR might consider soliciting feedback letters from its clients to get a better idea of the qualitative if not quantitative value of these and other ad hoc services it provides.

Estimated Impact -- Enormous, through new standards. (We have not yet figured out a way to estimate its dollar value even roughly.)

9. *Overall Valuation of Ad Hoc Consulting*

One way to estimate the value of ad hoc consulting is to price out the time spent on it. This is a minimum valuation, since a few minutes consulting by an expert CFR staffer can replace 1 - 2 days or more of searching for answers and possibly not getting as competent an answer. A second approach is to try to put some value on the different types of requests in terms of the expense likely to have been incurred to obtain the same information. The latter approach is probably more realistic. Also, many consultants would require a minimum retainer to provide any information.

For hourly pricing, $100 - 200 per hour is a reasonable range for top senior staff (loaded.) For the valuation approach, $500 - 1000 is reasonable per technical query. We use both for different levels of questions. Any "big hits" -- secondary impacts beyond the value of the consulting time -- are discussed separately in examples here or elsewhere. They add to the raw value of the consulting.

The number of requests to CFR can be estimated as follows: Ten of the 12 senior researchers or managers interviewed averaged about one consulting call/day. One or two received calls one every 2 to 5 days, and two received calls an average of 2 - 3 times per day. Assuming those thought to be most prolific were selected for us to interview, we assume the rate for half of the staff is 1/4 - 1/2 call per day, and 1/10 for the rest. That would yield 10 + (1/4 - 1/2) 40 + 1/10 (28) = 25 - 35 calls/day. According to the front office secretaries, they receive 5 - 10 requests per day, but perhaps one or two times that many go direct to the staff, or 10 - 30 per day by that count. Let us estimate:

25 per day "consulting,"

10 per day bulletin board,

6 per day library responses or bibliography requests

41 per day total

For the technical consulting, estimate 1/2 at \$150/hour, (time)

1/2 at \$1000 (valuation)

Then $25 \left(\frac{\$150 + \$1000}{2}\right) = \$14{,}400$ per day

Assuming \$100 average value for other contacts,

16 x \$100 = \$1600 per day.

Total value per day: \$16,000

per year: \$16,000 x 200 = \$3.2 Million [35]

Again, note this is <u>without</u> estimating the impact of the information provided, which is included elsewhere only in small part.

[35] One of the most widely known and frequently called upon CFR "consultants," Bud Nelson, estimated he was receiving about 5 calls every 2 days. A call by call estimate of the value of the services rendered averaged about \$1000 per contact, so the \$600 per average call may be about the right order of magnitude.

- - - * * * - - -

SUMMARY

Table 2 summarizes the various estimated impacts of the components of the CFR program. They are arrayed against estimates of the component costs of fire. [36]

As has been discussed, CFR's program has made a great contribution to life safety in the United States and has saved business billions of dollars in losses and unnecessary costs of fire. A much greater impact can be achieved with a few millions of dollars more investment in the CFR program each year -- the enhanced budgets.

---

[36] The estimated cost components are regrouped from "A First Pass at Computing the Cost of Fire in a Modern Society," William P. Meade, December 1990.

Table 2. IMPACT OF CFR PROGRAM -- SUMMARY

Cost of Fire ($ Billions)	Technology Area	Annualized CFR Impact	
		Impact at Baseline Budget ($ Billions)	Additional Impact With Enhanced Budget ($ Billions)
A. Losses			
Res. Property $4.0			
Res. Deaths and Injuries 7.3			
	Detectors (Property)	.05-.5	.09
	Detectors (Deaths)	.15-.3	1.2-2.4
	Furniture	.09	
	Carpets	.01+	
	Mattresses	.08	
	Child Sleepwear	.04	
	Designer Polymers		.1-.5 (property) .2-.8 (lives)
	Fire-safe Cigarettes	1.0-1.5	
	Woodstove Installation	.1-.2	
	Inhalation Toxicity	.15-1.5+	
	Sub-Total	1.7-4.2	1.6-3.8

Table 2. IMPACT OF CFR PROGRAM -- SUMMARY (Continued)

Cost of Fire ($ Billions)	Technology Area	Annualized CFR Impact: Impact at Baseline Budget ($ Billions)	Annualized CFR Impact: Additional Impact With Enhanced Budget ($ Billions)
A. Losses (Cont'd.)			
Non-Res. Property* 4.9			
Non-Res. Deaths and Injuries 1.8			
	Detectors		.2-.6
	Sprinklers	.2	.2-.4
	Halon Replacement	.1-.15	.04-.2
	Hotel Investigations	.02	
	Furniture Flammability Standards	.2-.3	
	Smoke Control Systems	.08	
	Aircraft Cabin Materials	.01	
	Sub-Total	.6-.8	.4-1.2
Residential Interruption 0.8		Not Estimated	Not Estimated
Business Interruption 8.4		Not Estimated	Not Estimated

*Industrial and Other Property

Table 2. IMPACT OF CFR PROGRAM -- SUMMARY (Continued)

Cost of Fire ($ Billions)		Technology Area	Annualized CFR Impact	
			Impact at Baseline Budget ($ Billions)	Additional Impact With Enhanced Budget ($ Billions)
A. Losses (Cont'd.)				
Product Liability	3.5			
		Children's Sleepwear	.01	
		Furniture, Carpets, Mattresses	.03-.06	
		HAZARD I Product Modeling	.01-.02	.03-.06
		HAZARD I Sprinkler Module		.03
		Aircraft Cabin Materials	.1-.14	
		Other	.04	
		Sub-Total	.2-.3	.06-.09

Table 2. IMPACT OF CFR PROGRAM -- SUMMARY (Continued)

Cost of Fire ($ Billions)		Technology Area	Annualized CFR Impact: Impact at Baseline Budget ($ Billions)	Annualized CFR Impact: Additional Impact With Enhanced Budget ($ Billions)
B. Insurance	5.7		Not Estimated	Not Estimated
C. Fire Service				
Costs	39.6*			
Deaths & Inj.	3.6			
		Compressed Air Foam	.01+	
		Fire Demand Model	.08-.4	
		Firefighter Outfits Testing	.1+	
		Advanced Suppression		.4-2.0
		HAZARD I-II Preplanning		.2
		Navy Trainer	.01	
		Sub-Total	.2-.5	.6-2.2

*Does not include cost of armed services firefighting

Table 2. IMPACT OF CFR PROGRAM -- SUMMARY (Continued)

Cost of Fire		Technology Area	Annualized CFR Impact	
			Impact at Baseline Budget $ Billions)	Additional Impact With Enhanced Budget ($ Billions)
D. Preventative	48.5			
Built into Structures	20.7			
		Sprinkler Engineering (DETACT Software)	.15	
		Sprinklered Healthcare Facilities	.1+	
		HAZARD I	1-2	2.0
		Sprinkler Module for HAZARD I		.03
		Advanced Sprinkler System		.6
		Halon Replacement	1+	
		Fire Safety System Evaluation	.2	4.0
		Smoke Control Systems	.1?	
		Sub-Total	2.6-3.6	6.6

Table 2. IMPACT OF CFR PROGRAM -- SUMMARY (Continued)

Cost of Fire ($ Billions)		Technology Area	Annualized CFR Impact: Impact at Baseline Budget ($ Billions)	Annualized CFR Impact: Additional Impact With Enhanced Budget ($ Billions)
D. Preventative (Cont.)				
Built Into Equip.	18.0	HAZARD I Product Design		.8-1.6
		Avoidance of Invalid Product Standards	.1+	
Standards	0.2	HAZARD I Enhanced and HAZARD II	Not Estimated	.02-.04
Retardants/Testing	2.5	Inhalation Toxicity	.01+	.1+
		Designer Polymers		.01
		Efficient Fire Tests	.01	
		Modernized Fire Tests		.1-1
		Sub-Total (Retardants)	.02	.21-1.21
Fire Maintenance	6.5		Not Estimated	Not Estimated
Disaster Recovery	0.6	Oil Spill Burns	.1	
		Burning in Dumps	.01+	
		Sub-Total (Disaster)	.11	
TOTALS	128.1		5.6-9.4	10.4-16.7

NIST-114A (REV. 3-90)	U.S. DEPARTMENT OF COMMERCE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY	1. PUBLICATION OR REPORT NUMBER NIST-GCR-91-591
	BIBLIOGRAPHIC DATA SHEET	2. PERFORMING ORGANIZATION REPORT NUMBER
		3. PUBLICATION DATE June 1991

4. TITLE AND SUBTITLE

Estimated Impact of the Center for Fire Research Program on the Costs of Fire

5. AUTHOR(S)

Philip Schaenman

6. PERFORMING ORGANIZATION (IF JOINT OR OTHER THAN NIST, SEE INSTRUCTIONS)

TriData, Corp.
Arlington, VA

7. CONTRACT/GRANT NUMBER

43NANB107753

8. TYPE OF REPORT AND PERIOD COVERED

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (STREET, CITY, STATE, ZIP)

U.S. Department of Commerce
National Institute of Standards and Technology
Gaithersburg, MD 20899

10. SUPPLEMENTARY NOTES

11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

The Center for Fire Research (CFR) has had a huge impact on reducing casualties and losses from fires. It also has helped stimulate new industries, and saved industry enormous sums by engineering fire safety better, averting business disruption, reducing liability, and in a number of other ways. The dividends of the past continue; CFR's budget essentially has been "paid" through the Year 2100 by even the most conservative estimates of its impact.

This was a first, brief effort to estimate the magnitude of the CFR impact, and how it is distributed across the major components of the total cost of fire. More work is needed on virtually every aspect of the estimation procedures used here.

CFR's program has made a great contribution to life safety in the United States and has saved business billions of dollars in losses and unnecessary costs of fire. A much greater impact can be achieved with a few millions of dollars more investment in the CFR program each year - the enhanced program.

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)

building codes; building design; costs; economic factors; fire detection; fire losses; fire models; fire research; fire suppression; fire tests; toxicity

13. AVAILABILITY

- [X] UNLIMITED
- [ ] FOR OFFICIAL DISTRIBUTION. DO NOT RELEASE TO NATIONAL TECHNICAL INFORMATION SERVICE (NTIS).
- [ ] ORDER FROM SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, DC 20402.
- [X] ORDER FROM NATIONAL TECHNICAL INFORMATION SERVICE (NTIS), SPRINGFIELD, VA 22161.

14. NUMBER OF PRINTED PAGES

82

15. PRICE

A05

ELECTRONIC FORM